CLAIMS

1. An ion trap, comprising:

a three-dimensional rotationally symmetric ring electrode and two cap electrodes with surfaces facing toward the inside of the ion trap, said two cap electrodes being further composed of a plurality of component electrodes, the surfaces of said ring electrode and cap electrodes being shaped to reduce nonlinearity;

means for generating a time-varying, substantially quadrupole field, said means further compensating the nonlinearity induced quadrupole field distortion;

means for ions mass analysis, said means utilizing the nonlinearity for providing higher mass resolving power.

2. An ion trap, comprising:

a rotationally symmetric ring electrode cut, in parallel to its central axis, into an even number, equal or larger than four, of equal parts and two cap electrodes with surfaces facing toward the inside of the ion trap, said two cap electrode being further composed of a plurality of component electrodes, the surfaces of said ring electrode and cap electrodes being shaped to reduce nonlinearity;

means for electrically operating said even number of equal parts to switch said ion trap operation between a three-dimensional mode and a two-dimensional mode;

means for generating a time-varying, substantially quadrupole field, said means further compensating the nonlinearity induced quadrupole field distortion when said ion trap operating under the three-dimensional mode;

means for generating a linear RF multipole field when said ion trap operating under the two-dimensional mode.

3. An ion trap, comprising:

a three-dimensional, rotationally symmetric ring electrode and two cap electrodes with hyperbolic surfaces facing toward the inside of said ion trap, each of said two cap electrodes being further composed of a first hyperbolic cone electrode and a second disk electrode,

a RF or periodic circuitry constructed and arranged for applying a RF or periodic voltage to said ring electrode to generate a main quadrupole field in said ion trap;

an AC circuitry constructed and arranged for applying an AC voltage to said disk electrodes of said two cap electrodes to generate a dipole field in said ion trap;

a DC circuitry constructed and arranged for applying an DC voltage to said cone electrodes of said two cap electrodes to generate an electrically variable electrostatic octopole field in said ion trap.

4. An ion trap, comprising:

a three-dimensional, rotationally symmetric ring electrode and two cap electrodes, the surface of each one of the cap electrodes consists of first portion of spherical surface and a second portion of cone surface; the cross-sectional surface of the ring electrode consists of a portion of circle and two straight lines jointed in orthogonal to the circle; the surfaces of the two cap electrodes facing toward the inside of said ion trap.

5. The ion trap of claim 4 wherein said cap electrodes being further divided into a plurality of sets of component electrodes.

6. The ion trap of claim 5 wherein said plurality of sets of component electrodes include a cone and a disk electrodes.

7. The ion trap of claim 5 further comprising:

a RF or periodic circuitry constructed and arranged for applying a RF or periodic voltage to said ring electrode to generate a main quadrupole field in said ion trap;

an AC circuitry constructed and arranged for applying an AC voltage to a first set of said plurality of sets of component electrodes to generate a main dipole field in said ion trap;

a DC circuitry constructed and arranged for applying an DC voltage to a second set of said plurality of sets of component electrodes to generate an electrically variable electrostatic octopole field in said ion trap.

8. A two-dimensional ion trap, comprising:

two trapping plates located in the two terminals of the ion trap device;

a set of four predetermined surface-shaped rods located in the center;

a set of electrodes located between the set four predetermined surface-shaped rods;

a control circuitry for applying a predetermined voltage to said two trapping plates.

9. The ion trap of claim 8 further comprising a set of short quadrupole rods located between said predetermined surface-shaped rods and said two trapping plates.

10. The ion trap of claim 8 wherein said a set of electrodes being further composed of a set of four smaller diameter's cylindrical rods.

11. The ion trap of claim 8 wherein said a set of electrodes being further composed of a set of four slice electrodes.

12. The ion trap of claim 8 further comprising:

a RF circuitry constructed and arranged for applying a RF voltage to said set of four predetermined surface shaped rods to generate a main two dimensional quadrupole field;

an AC offset circuitry constructed and arranged for applying an AC voltage to a pair of said set of four predetermined surface shaped rods to

generate a main dipole field;

a DC circuitry constructed and arranged for applying a DC voltage to said set of electrodes to superimposes a two dimensional electrically variable electrodes octopole field within said two dimensional quadrupole field.

13. The ion trap of claim 8 wherein said predetermined surface-shaped is quadrupole surface-shaped.

14. The ion trap of claim 8 wherein said predetermined surface-shaped is cylinder surface-shaped.

15. A tandem mass spectrometers, comprising:

a collision cell to perform mass fragment, said collision cell having the structure of ion trap as in claim 8.

16. An ion trap, comprising:

a three-dimensional rotationally symmetric ring electrode and two cap electrodes, the ring electrode being divided, in parallel to its central axis, into a plurality of even number of component electrodes, said component electrodes being electrically isolated from each other, the surfaces of the two cap electrodes facing toward the inside of said ion trap.

a mechanism constructed and arranged for switching said ion trap to operate between a three-dimensional quadrupole ion trap mode and a two-dimensional linear ion trap mode.

17. The ion trap of claim 16 wherein said plurality of even number of component electrodes being equally divided.

18. The ion trap of claim 16 wherein said plurality of even number of component electrodes being unequally divided.

19. The ion trap of claim 16 wherein said plurality of even number of component electrodes being symmetrically divided.

20. The ion trap of claim 16 wherein said plurality of even number of

component electrodes being non-symmetrically divided.

21. The ion trap of claim 17 wherein said even number is chosen from the group of four, six and eight.

22. The ion trap of claim 16 wherein said mechanism constructed and arranged to apply a RF or periodic voltage, with identical polarity or phase, to said plurality of even number of component electrodes to operate said ion trap under the three-dimensional quadrupole ion trap mode.

23. The ion trap of claim 16 wherein said plurality of even number of component electrodes being grouped into a first set composed of odd numbered component electrodes and a second set composed of even numbered component electrodes, said mechanism constructed and arranged to apply a first RF or periodic voltage to the first set electrodes, and a second RF or periodic voltage to the second set electrodes, to operate said ion trap under the two-dimensional linear ion trap mode; the first and second RF or periodic voltages having opposite polarities or phase deference of 180 degree.

24. The ion trap of claim 16 wherein said mechanism being an electrical switching device.

25. The ion trap of claim 16 wherein said ion trap operates to trap external inlet ions under the two-dimensional linear ion trap mode.

26. The ion trap of claim 16 wherein said ion trap operates to analyze the trapped ion-mass under the three-dimensional quadrupole ion trap mode.

27. The ion trap of claim 16 wherein said two cap electrodes having hyperbolic surfaces facing toward the inside of said ion trap, each of said two cap electrodes being further composed of a first hyperbolic cone electrode and a second disk electrode.

28. The ion trap of claim 27 further comprising:

a RF or periodic circuitry constructed and arranged for applying a

RF or periodic voltage to said ring electrode to generate a main quadrupole field in said ion trap;

an AC circuitry constructed and arranged for applying an AC voltage to said disk electrodes of said two cap electrodes to generate a dipole field in said ion trap;

a DC circuitry constructed and arranged for applying an DC voltage to said cone electrodes of said two cap electrodes to generate an electrically variable electrostatic octopole field in said ion trap.

29. A method of operating an ion trap in claim 3, said method comprising:

keeping amplitude and frequency of the RF voltage or amplitude and period of the periodic voltage at predetermined values;

simultaneously sweeping or scanning the amplitude of the DC voltage and the amplitude and frequency of the AC voltage vs. time to eject ion mass from the ion trap one after another.

30. A method of operating an ion trap in claim 7, said method comprising:

keeping amplitude and frequency of the RF voltage or amplitude and period of the periodic voltage at predetermined values;

simultaneously sweeping or scanning the amplitude of the DC voltage and the amplitude and frequency of the AC voltage vs. time to eject ion mass from the ion trap one after another.

31. A method of operating an ion trap in claim 12, said method comprising:

keeping amplitude and frequency of the RF voltage or amplitude and period of the periodic voltage at predetermined values;

simultaneously sweeping or scanning the amplitude of the DC voltage and the amplitude and frequency of the AC voltage vs. time to eject ion mass from the ion trap one after another.

32. A method of operating an ion trap in claim 28, said method comprising:

keeping amplitude and frequency of the RF voltage or amplitude

and period of the periodic voltage at predetermined values;

simultaneously sweeping or scanning the amplitude of the DC voltage and the amplitude and frequency of the AC voltage vs. time to eject ion mass from the ion trap one after another.

33. A method of operating an ion trap in claim 3, said method comprising:

keeping the frequency of the RF voltage or the period of the periodic voltage and the frequency of the AC voltage at predetermined values;

Simultaneously sweeping or scanning the amplitudes of the RF voltage or the periodic voltage, the AC voltage and the DC voltage vs the time to eject ion mass from the trap one after another.

34. A method of operating an ion trap in claim 7, said method comprising:

keeping the frequency of the RF voltage or the period of the periodic voltage and the frequency of the AC voltage at predetermined values;

Simultaneously sweeping or scanning the amplitudes of the RF voltage or the periodic voltage, the AC voltage and the DC voltage vs the time to eject ion mass from the trap one after another.

35. A method of operating an ion trap in 12, said method comprising:

keeping the frequency of the RF voltage or the period of the periodic voltage and the frequency of the AC voltage at predetermined values;

Simultaneously sweeping or scanning the amplitudes of the RF voltage or the periodic voltage, the AC voltage and the DC voltage vs the time to eject ion mass from the trap one after another.

36. A method of operating an ion trap in claim 28, said method comprising:

keeping the frequency of the RF voltage or the period of the periodic voltage and the frequency of the AC voltage at predetermined

values;

Simultaneously sweeping or scanning the amplitudes of the RF voltage or the periodic voltage, the AC voltage and the DC voltage vs the time to eject ion mass from the trap one after another.

37. A method of operating an ion trap in claim 3, said method comprising:

setting the frequency of the AC voltage to zero;

setting the amplitude of the AC voltage to be different from the amplitude of the DC voltage or zero;

keeping the frequency of the RF voltage or the period of the periodic voltage at predetermined value;

Simultaneously sweeping or scanning the amplitudes of the RF voltage and DC voltage vs. time to eject ion mass from the trap one after another.

38. A method of operating an ion trap in claim 7, said method comprising:

setting the frequency of the AC voltage to zero;

setting the amplitude of the AC voltage to be different from the amplitude of the DC voltage or zero;

keeping the frequency of the RF voltage or the period of the periodic voltage at predetermined value;

Simultaneously sweeping or scanning the amplitudes of the RF voltage and DC voltage vs. time to eject ion mass from the trap one after another.

39. A method of operating an ion trap in claim 12, said method comprising:

setting the frequency of the AC voltage to zero;

setting the amplitude of the AC voltage to be different from the amplitude of the DC voltage or zero;

keeping the frequency of the RF voltage or the period of the periodic voltage at predetermined value;

Simultaneously sweeping or scanning the amplitudes of the RF voltage and DC voltage vs. time to eject ion mass from the trap one after another.

40. A method of operating an ion trap in claim 28, said method comprising:

setting the frequency of the AC voltage to zero;

setting the amplitude of the AC voltage to be different from the amplitude of the DC voltage or zero;

keeping the frequency of the RF voltage or the period of the periodic voltage at predetermined value;

Simultaneously sweeping or scanning the amplitudes of the RF voltage and DC voltage vs. time to eject ion mass from the trap one after another.

41. The ion trap of claim 3 wherein said DC circuitry is controlled to adjust said electrically variable electrostatic octopole field to compensate distortion of said quadrupole field.

42. The method of claim 29 wherein said ion trap is sealed in a vacuum chamber which is further pumped by a vacuum pump to provide a predetermined level of gas pressure in the trap, the method further adjusts the RF voltage, the DC voltage and the AC voltage along with the gas pressure in the trap to eject the ions of the ion trap with maximum or near optimal jumping distance to optimize the mass resolving power.

43. An ion trap system, comprising:

an ion trap as in claim 3, sealed within a vacuum chamber being pumped by a vacuum pump to provide gas pressure in the ion trap.

44. An ion trap system, comprising:

an ion trap as in claim 7, sealed within a vacuum chamber being pumped by a vacuum pump to provide gas pressure in the ion trap.

45. An ion trap system, comprising:

an ion trap as in claim 12, sealed within a vacuum chamber being pumped by a vacuum pump to provide gas pressure in the ion trap.

46. An ion trap system, comprising:

an ion trap as in claim 28, sealed within a vacuum chamber being pumped by a vacuum pump to provide gas pressure in the ion trap.

47. The ion trap system of claim 43 wherein said vacuum chamber having vacuum in the range between 10^{-2} to 10^{-1} mbar.

48. The ion trap system of claim 43 wherein said DC circuitry being constructed and arranged for applying an DC voltage to adjust the intensity of said electrically variable electrostatic octopole field in said ion trap to optimize the mass resolving power when said gas pressure is higher.

49. A method for providing ions into ion trap system of claim 43, comprising:

introducing gas-phase molecules through a membrane into an ionization area;

ionizing said gas-phase molecules by a radioactive Ni beta source or multi-photon ionization of laser.

50. The ion trap system of claim 44 wherein said vacuum chamber having vacuum in the range between 10^{-2} to 10^{-1} mbar.

51. The ion trap system of claim 44 wherein said DC circuitry being constructed and arranged for applying an DC voltage to adjust the intensity of said electrically variable electrostatic octopole field in said ion trap to optimize the mass resolving power when said gas pressure is higher.

52. A method for providing ions into ion trap system of claim 44, comprising:

introducing gas-phase molecules through a membrane into an ionization area;

ionizing said gas-phase molecules by a radioactive Ni beta source or multi-photon ionization of laser.

53. The ion trap system of claim 45 wherein said vacuum chamber having

vacuum in the range between 10^{-2} to 10^{-1} mbar.

54. The ion trap system of claim 45 wherein said DC circuitry being constructed and arranged for applying an DC voltage to adjust the intensity of said electrically variable electrostatic octopole field in said ion trap to optimize the mass resolving power when said gas pressure is higher.

55. A method for providing ions into ion trap system of claim 45, comprising:

    introducing gas-phase molecules through a membrane into an ionization area;

    ionizing said gas-phase molecules by a radioactive Ni beta source or multi-photon ionization of laser.

56. The ion trap system of claim 46 wherein said vacuum chamber having vacuum in the range between 10^{-2} to 10^{-1} mbar.

57. The ion trap system of claim 46 wherein said DC circuitry being constructed and arranged for applying an DC voltage to adjust the intensity of said electrically variable electrostatic octopole field in said ion trap to optimize the mass resolving power when said gas pressure is higher.

58. A method for providing ions into ion trap system of claim 46, comprising:

    introducing gas-phase molecules through a membrane into an ionization area;

    ionizing said gas-phase molecules by a radioactive Ni beta source or multi-photon ionization of laser.

59. An ion trap system, comprising:

    A three-dimensional ion trap, said ion trap being sealed within a vacuum chamber, said vacuum chamber has vacuum in the range between 10^{-2} to 10^{-1} mbar.

60. The ion trap system of claim 59 wherein said three-dimensional ion trap is a Paul trap.

61. A three-dimensional ion trap, comprising:

A set of cap electrodes, each of said cap electrodes being further divided into a predetermined number of component electrodes having predetermined shape,

a DC circuitry constructed and arranged for applying an DC voltage to a pair of said component electrodes of said cap electrodes to generate an independent electrically variable electrostatic octopole field in said ion trap.

62. An ion trap, comprising:

a ring electrode, the ring electrode being divided, in parallel to its central axis, into a plurality of even number of component electrodes, said component electrodes being electrically isolated from each other;

a mechanism constructed and arranged for switching said ion trap to operate between a three-dimensional quadrupole ion trap mode and a two-dimensional linear ion trap mode.

63. The ion trap of claim 62 wherein said ring electrode is a cylindrical ring electrode.